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Growth, Yield and Harvesting

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PRODUCTIVE CAPABILITY

The size of the investment in intensive stand management should be governed by the productive capability of the site and species as indicated by growth studies. The yields reported here are from studies in which thinning was the sole management practice used. In the future, we can expect greater yields than those cited where site preparation and other recently developed techniques are utilized.

LOBLOLLY PINE

Loblolly pine is the most widely planted commercial species in the South because of its wide range, growth habits, adaptability to site conditions and economic use. Growth and yield of planted stands are influenced by several factors, but the most important are initial spacing and site quality. Example: In an unthinned 17-year-old plantation in southwest Louisiana, both cubic-foot volumes and tree diameters were influenced by planting density (300 to 1,200 trees per acre) and site index (Tables 1 and 2).

Note: This is the third and final Bulletin which summarizes the information presented at two Symposiums on Management of Young Pines held in Alexandria, Louisiana, and Charleston, South Carolina, during 1974. For those who want more details, write to the information sources listed on the back.

Within each site, a density of 1,200 trees per acre consistently had about 1.5 times as much volume as 300 trees per acre. Most of the gains occurred between 300 and 600 trees per acre. Volumes on site 105 were 2.4 to 3.0 times greater than on site 70, and the relationship was linear in each density level.

Maximum yields were obtained with progressively higher planting densities as site improved. For sites 70 and 75, 800 planted trees per acre appeared to be optimum. Yields were highest on sites 80 and 85 at densities of 900; 1000 trees per acre were best on sites 90 and 95; and 1,100 trees per acre produced highest yields on sites 100 and 105 feet.

Table 1.—Estimated yields (inside bark) per acre at age 17 years for loblolly pine trees 4.6 inches d.b.h. and larger to a 4.0 inch top

Trees planted per acre (No.)	Site index 70	75	80	85	90	95	100	105
					cubic feet			
300	573	729	889	1,052	1,221	1,395	1,574	1,760
400	798	967	1,137	1,311	1,488	1,670	1,856	2,048
500	930	1,112	1,293	1,476	1,662	1,852	2,045	2,244
600	1,003	1,197	1,390	1,583	1,777	1,975	2,175	2,380
700	1,035	1,242	1,446	1,649	1,852	2,057	2,265	2,476
800	1,038	1,257	1,472	1,685	1,897	2,110	2,324	2,542
900	1,018	1,250	1,476	1,698	1,919	2,139	2,361	2,585
1,000	979	1,224	1,461	1,694	1,923	2,151	2,380	2,610
1,100	927	1,184	1,432	1,674	1,913	2,149	2,384	2,621
1,200	862	1,132	1,392	1,643	1,890	2,134	2,377	2,620

Source: Thomas E. Campbell and William F. Mann, Jr.

Table 2.—Estimated average d.b.h. of loblolly pine trees 3.6 inches and larger

Trees planted per acre (No.)	Site index 70	75	80	85	90	95	100	105
				inches				
300	7.8	7.9	8.1	8.4	8.6	8.9	9.2	9.5
400	7.0	7.1	7.3	7.5	7.8	8.0	8.3	8.6
500	6.5	6.6	6.8	7.0	7.2	7.4	7.7	8.0
600	6.2	6.3	6.4	6.6	6.8	7.0	7.2	7.5
700	6.0	6.0	6.1	6.3	6.5	6.7	6.9	7.2
800	5.8	5.8	5.9	6.1	6.2	6.4	6.7	6.9
900	5.7	5.8	5.8	5.9	6.1	6.2	6.5	6.7
1,000	5.7	5.7	5.7	5.8	6.0	6.1	6.3	6.6
1,100	5.7	5.7	5.7	5.8	5.9	6.0	6.2	6.4
1,200	5.8	5.7	5.7	5.8	5.9	6.0	6.2	6.4

Source: Thomas E. Campbell and William F. Mann, Jr.

Initial planting density had a stronger influence on average diameter at age 17 than did site index. From the closest to the widest spacing, diameters increased by 2.0 inches on site 70 and 3.1 inches on site 105. The greatest differences occurred at the lower planting densities of 300 to 600 trees, with diameter curves for all sites leveling off at about 1,000 trees per acre. The influence of site index was also greatest in the lower densities, increasing from site 70 to 105 by 1.7 inches for 300 trees and only 0.6 inch for 1,200 trees.

Example: In a 10-year-old plantation in South Carolina, basal area and total cubic volume increased with increasing density, while average diameter decreased (Table 3). Cordwood production data are erratic, since the stands are at an age when many trees are at the threshold of merchantability, but average cord volume is greatest at the 6 x 6 and 8 x 8 spacings. As anticipated, production was directly related to site index.

At age 25, an unthinned loblolly pine stand near Homer, Louisiana, planted at an initial spacing of 10 x 10 feet, was superior to dense stands in both average tree size and cubic volume per acre (Table 4).

Importance of spacing and site. *In a 10-year old loblolly spacing study in South Carolina, this 8′ x 8′ spacing produced more merchantable volume than 4′ x 4′ spacings. The 4′ x 4′ spacings had the highest total cubic volume.*

Lacking early thinnings, mortality has been heavy in all but the 10 x 10 spacing. While average height is not the best indicator of the effect of stand density on height growth, measurements of the dominants on each plot indicate that height growth has been slowed on the 4 x 4 foot spacing. While the 10 x 10 spacing

Table 3.—Effects of spacing on stand characteristics of planted loblolly pine at age 10

Initial spacing (feet)	Avg. DBH (inches)	Basal area per acre (sq. ft.)	Average total height (feet)	Merch. cords/A	Total cubic feet per acre (Inside bark)	Number trees per acre
4 x 4	3.5	132	28	4.7	1561	2021
6 x 6	4.5	119	29	8.8	1447	1109
8 x 8	5.3	91	30	8.7	1110	597
10 x 10	5.7	71	29	7.5	880	403
12 x 12	6.3	60	30	6.4	742	276
14 x 14	6.6	52	29	4.8	599	215

Source: E. G. Owens

Table 4.—Characteristics of planted loblolly pines at age 25

Initial spacing (feet)	Trees per acre (number)	Average d.b.h. (inches)	Average height (feet)	Basal area (sq. ft.)	Volume per acre (cu. ft.)
4 x 4	968	5.6	54	180	2604
6 x 6	610	7.3	60	190	3948
6 x 8	487	7.8	62	172	3745
8 x 8	455	8.4	62	182	3885
10 x 10	352	9.9	73	194	4576

Source: Robert K. Shepard, Jr.

Table 5.—Average sawtimber production per acre, loblolly trees 9.6 inches d.b.h. and up

Stand age	Site index 80 thinned	Site index 80 check	Site index 90 thinned	Site index 90 check	Site index 100 thinned	Site index 100 check	Site index 110 thinned	Site index 110 check
	Board feet (International ¼-inch rule)							
Years								
15	310		750		3,650	3,440	4,350	1,240
20	620	740	3,260		5,990	5,090	5,430	6,630
25	2,220	2,120	7,450	3,930	10,170	8,040	9,840	12,500
30	4,340	3,880	11,650	8,590	15,600	12,080	16,380	18,840
35	6,500	5,950	15,850	13,890	21,690	16,920		
40	8,700	8,290	20,040	19,840	27,880	22,290		
45	10,950	10,840	24,240	26,440	33,580	27,930		
50	13,230	13,550	28,430	33,680	38,210	33,570		
55	15,560	16,360	32,660	41,570	41,180	38,950		
60	17,930	19,220	36,830	50,110	41,930	43,790		

Source: Edward A. Andrulot and Hamlin L. Williston

excelled here, other studies indicate that for all-purpose spacing, 8 x 8 is the best.

In natural stands, time and intensity of thinning are important. Data from 28 Forest Service plots at Urania, Louisiana, some established as long ago as 1915, bear this out (Table 5). Lack of sufficient replication is responsible for seeming irregularities in the yields. From these and the other loblolly growth data we can conclude that early thinnings bring early monetary returns and help to maintain rapid diameter growth on the residuals, but do not generally increase total cubic-foot yield. With early thinnings, earlier sawlog cuts are possible. Acceptable periodic annual increments of both cubic and board feet are maintained long after the short rotation ages of 25 to 30 years. Certainly, small landowners should consider employing rotations longer than those currently in vogue.

SLASH PINE

We now know that stand density affects the height growth of many species, especially slash pine. As shown in Table 6, site index values decrease as density increases if soil conditions are constant across the density range. The importance of density to volume growth of slash pine is shown in Table 7.

Volume growth was reduced the most by early and heavy thinning, and was best on the unthinned check. The excellent growth on all treatments is noteworthy, with averages for the 14-year study period ranging from 3.2 to 4.0 cords per acre.

Table 6.—Fifty-year slash pine site indexes for varying densities

Number surviving trees per acre: 200	400	600	800	1000	1200
Site index (feet)					
61	60	59	58	56	55
71	70	68	67	66	64
82	80	78	77	75	73
92	90	88	86	84	83
102	100	98	96	93	92

Source: Frank A. Bennett

Table 7.—Periodic annual cordwood volume growth per acre for trees 3.6 inches d.b.h. and larger

Age at first cut, and stocking level	10-13 years	13-16 years	16-19 years	19-24 years	10-24 years
			Cords a/		
10 years					
B.A. 70	3.2	2.8	2.8	3.6	3.2
B.A. 85	3.1	3.1	3.2	4.1	3.5
B.A. 100	3.6	3.5	3.4	4.2	3.7
13 years					
B.A. 70	4.1	2.6	2.8	3.6	3.3
B.A. 85	3.6	3.0	3.1	4.1	3.6
B.A. 100	3.8	3.0	3.4	4.4	3.8
16 years					
B.A. 70	3.8	3.4	2.4	3.8	3.4
B.A. 85	3.9	3.6	2.7	4.6	3.8
B.A. 100	3.1	3.9	2.9	4.5	3.7
Unthinned check	3.3	3.3	3.6	5.1	4.0

a/ Standard rough cords, 90 cubic feet outside bark per cord.

Source: Donald P. Feduccia

Height affected by density. *Research has shown that height growth of slash pine can be adversely affected by high stand density. At Cordele, Georgia the natural regenerated slash pine stand in the foreground was thinned to 10 x 10 spacing at 3 years. At age 17, dominants and co-dominants averaged 42' in height on the 10' x 10' spacings and 32' in height on the unthinned plot in the background.*

LONGLEAF PINE

In many longleaf plantations, survival is poor and early height growth is slow. Merchantable yields are generally less than in young plantations of other pine species. In a Louisiana study on site 78 (base age 50), merchantable volume and diameter growth were related to initial spacing, residual density after thinning, and age. Periodic annual growth from age 20 to 35 years exceeded two cords per acre in several treatments. The maximum yield was 53 cords per acre at age 35 (Table 8).

Improvements in nursery practices and planting techniques for longleaf plus the development of brownspot resistant strains, should result in acceptable growth and yields.

Complete site preparation is recommended to destroy competition and remove brownspot inoculum by eliminating residual longleaf seedlings and saplings. Observations on medium sites in south Alabama indicate that complete site preparation enables the majority of planted seedlings to grow out of the grass stage within three years and thereby largely escape infection.

From limited data on the growth and yield of young natural longleaf on medium sites (index 70 to 80), the following conclusions have been drawn:

—Stands can produce 1.2 to 1.5 cords per acre, mean

Table 8.—Actual total yield and mean diameter of all longleaf trees at age 35 years

Initial spacing (feet)	Treatment	Volume per acre	Diameter
		Cords[1]	Inches
4.3 by 4.3	BA 60	44.9	8.7
	BA 80	50.2	8.9
	BA 100	53.4	8.0
	Crop trees	34.7	9.3
5.2 by 5.2	BA 60	41.4	9.7
	BA 80	39.1	8.8
	BA 100	42.6	8.8
	Crop trees	31.0	10.0
6.2 by 6.2	BA 60	40.9	10.7
	BA 80	34.4	10.5
	BA 100	42.0	10.4
	Crop trees	28.9	9.9
13.1 by 13.1[2]	No pruning	21.4	11.9
	Pruned to 17 feet	19.3	11.7
	Pruned to 34 feet	12.2	11.4
	Pruned 2/3 height	12.9	11.4

1/Standard rough cords in trees over 3.5 inches d.b.h. to a 4-inch top (o.b.)
2/Plots in the 13.1-foot spacing were not thinned.

Source: Richard E. Lohrey

Longleaf regeneration. *Complete site preparation before planting enabled this 4-year old longleaf plantation to grow out of the grass stage rapidly.*

annual increment, to age 30 and 1 to 1.2 cords to age 40.

—Five-year periodic annual increment can be as much as 2 to 4 cords between ages 20 to 30.

—A density range of 500 to 1,000 established trees per acre appears to be optimum for maximizing early cord yields.

—When stands exceed 1,000 crop seedlings at age 5 to 10, precommercial thinning should be considered if maximum early yields are desired.

HARVESTING

Harvesting must be considered as part of the management cycle and planned for well in advance. A growing resistance to thinning by wood producers must be taken into consideration. Such factors as tree spacing, size of tree to be cut, and the possibility of lasting damage to the site will frequently determine the kind of logging equipment to employ. The final harvest should clear the site of all usable material and, to the extent possible, prepare the way for the next forest crop.

Because of its high mobility and relatively low cost to purchase and operate, the bobtail truck is ideally suited for many relatively accessible woodland ownerships across the South. On the proper site, the combination of operators and the bobtail truck provide the cheapest means of harvesting pulpwood if the haul isn't too long. Pulpwood in the six, seven, and eight-inch diameter range is most economically logged by using bobtail trucks or rubber-tired pre-haulers.

A fairly new innovation in shortwood harvesting has been the development of heavy machines that shear the tree from the stump, pass it through delimbing rings, and then through another shear that cuts the tree into the desired length pulpwood sticks. Production rates are high but its purchase cost is also high; it is primarily suited to row thinning, and operates most efficiently on large plantation ownerships.

When the timber diameter averages over nine inches, long length logging with four-wheel-drive, rubber-tired skidders and the knuckle boom loader becomes more economical. The skidders can handle large loads over wet ground and slopes of 40 percent or more. The system is very tree-diameter sensitive and if used in selective thinning is apt to damage the residual stand more than the shortwood systems.

Recently, an economical way to thin stands of small timber (less than seven inches in diameter) has been developed in which the entire tree is chipped. Although this logging system is not as tree-sensitive as other systems, the 40-hour production rate of 400 cords at six inches dbh falls to 350 cords for five-inch trees, and 280 cords for four-inch trees. This system has the disadvantage of high initial costs (investment in excess of $400,000). Total operating cost for a field-chipping operation is $125.00 per hour plus the

The old stand-by. *Despite many innovations in equipment, the bobtail truck and experienced chain saw operators on the proper site still provide the cheapest means of shortwood harvesting in the South.*

Chip Harvester. *A new development offers opportunities of greater utilization of individual trees and economy of operation under some circumstances.*

highway hauling cost. Included in the equipment are two rubber-tired feller bunchers equipped with accumulating shears, three grapple skidders, a chipper, four haul trucks, seven van trailers, a small dozer, a service truck, related tools and welding equipment. Disadvantages are:

—It requires more managerial skill than other systems.

—A high volume of timber is required to make the system operational.

—The system lacks mobility.

—Dirt is mixed with the chips.

—A lower pulp yield per ton of chips is realized.

INFORMATION SOURCES

Growth and Yield—

Slash Plantations—

Bennett, F. A., USFS, Box 3, Olustee, Fla. 32072
Feduccia, D. P., USFS, Pineville, La. 71360

Loblolly Plantations—

Campbell, T. E., USFS, Pineville, La. 71360
Goebel, N. B., Clemson University, S.C.
Mann, W. F., Jr., USFS, Pineville, La. 71360
Owens, E. G., Westvaco, Summerville, S.C.

Longleaf Plantations—

Lohrey, R. E., USFS, Pineville, La. 71360
Farrar, R. M., USFS, Box 769, Brewton, Ala. 36426

Naturally Established Loblolly—

Andrulot, E. A., Louisiana Tech., Ruston, La.
Harms, W. R., USFS, Federal Bldg., Charleston, S.C.
Langdon, O. G., USFS, Federal Bldg., Charleston, S.C.
Trousdell, K. B., USFS, Federal Bldg., Charleston, S.C.
Williston, H. L., USFS, Pineville, La. 71360

Harvesting—

Darwin, W. N., Jr., USFS, Forestry Sciences Lab, Athens, Ga.
Tufts, Donald, Pineville Kraft, Pineville, La.